forward so rapidly that important researches of the past four or five years are not found included in it. This defect, however, as intimated above, may be regarded as compensated for by the comprehensive and historical sweep which characterizes Luciani's survey of the subject. W. B. Cannon

The Wonder of Life. By J. Arthur Thomson. New York, Henry Holt and Company. 1914.

Once more we are indebted to Professor Thomson for a semipopular work on biology, this time with contents of a very miscellaneous character, better to reflect the varied aspects of living nature. We have, in fact, a biological (mainly zoological) scrap-book, full of interesting matters gleaned from more or less recent literature, carefully selected and digested for our benefit. All this is loosely thrown together under several general headings, "The Drama of Life," "The Haunts of Life," "The Insurgence of Life," "The Ways of Life," "The Web of Life," "The Cycle of Life" and "The Wonder of Life," with more than 300 separate minor topics. Each chapter is headed by a selection from the aphorisms of Goethe, as translated by Huxley. The book is admirably adapted for "supplementary reading" in a course on biology or zoology, or it might itself be made the basis of a seminar course. Its great value lies in its wide scope and breadth of view, with every emphasis on vital phenomena rather than on morphological details or classification. It is addressed, however, to an educated public, and even in places presupposes more zoological knowledge than most of us can boast. For example, on page 105 we are pulled up short by the startling announcement that "no one expects to find a Crustacean like *Byotrephes longimanus* in a pond." It is probably true that very few have ever approached a pond with any such expectation! Doubtless it is good for us, however, to bump now and again into things we do not understand, merely to diminish that conceit which too readily develops after reading discussions so lucid as those of Professor Thomson.

The specialist will here and there find things not quite up to date, or stated without sufficient reference to diverse points of view, but the general impression gained is that the work is admirably done, and that in all probability no other naturalist could have done it better, if so well. The illustrations, including many colored plates, are pleasing and instructive, but not up to the standard of the text. Some are really bad, as Fig. 81, a colored plate of leaf-insects (*Phyllium*). The coloring of the foliage, to correspond with the insects, is unnatural and without any adequate basis; while the insects are drawn from mounted specimens with the legs spread in the conventional way, without any reference to the plant on which they are supposed to be resting! The most ridiculous object is the young one, shown as resting on a nearly upright branch, with its legs waving wildly in the air. The whole thing is certainly, as it stands, a piece of "nature-faking." Fig. 39, representing young spiders, shows some of them with the head and thorax separate, like an insect.

There is a passage on page 595, beginning the discussion of the Transmissibility of Acquired Characters, which indicates that such transmission is perfectly easy in unicellular animals, which simply divide into two. Jennings has well shown the fallacy of this naïve conception, and it seems surprising that Professor Thomson should offer it, not merely as an idea, but as a well-known fact.

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SPECIAL ARTICLES

MICRODISSECTION STUDIES ON THE GERM CELL[1]

This paper records a continuation of the observations published recently[2] in Science on the male germ cells of the grasshopper, *Disosteira Carolina,* and of the cockroach, *Periplaneta Americana.* The cells were iso-

[1] Slightly modified from a paper read before the American Society of Zoologists, Philadelphia, December 29, 1914.

[2] Robert Chambers, Jr., "Some Physical Properties of the Cell Nucleus," Science, N. S., XL., p. 824, 1914.

lated and studied by means of microdissection and vital staining in a hanging drop of the insect body fluid in Barber's moist chamber.

The cytoplasm exhibits an extreme variability in its consistency. On tearing it may go into solution, setting free the nucleus and the cytoplasmic granules. Often the cytoplasm goes into solution with a rapidity suggestive of an explosion. A slight tearing of the surface is followed by a moment of apparent inactivity. Then comes a slight convulsive movement and the torn surface opens up, a swelling appearing especially at this place. Within a few seconds nothing remains but the nucleus and the mitochondria in the form of granules or a network. The nucleus in its turn swells and goes into solution. The mitochondria persist for a much longer time. Individuals are also met with whose cells retain their shape, the torn region being gradually obliterated by a closing in of the surrounding cytoplasm.

It is significant that all the cells of a given individual are constantly uniform in their behavior.

In an attempt to ascertain the cause for this variability in the consistency of the protoplasm a series of experiments has been planned, one of which is the investigation of the germ cells of food and water starved individuals. Cockroaches starved for three weeks in a dry heated room were found uniformly to possess germ cells remarkable for their toughness and resistance to mechanical injury.

"Physiological" salt solutions in various dilutions were all found to produce a swelling effect on the cell. The first evidence of this in isolated cells is the assumption of a spherical shape. The addition of a trace of egg albumin counteracts the swelling to a slight extent. As swelling proceeds the viscosity of the protoplasm at first increases, agglutination phenomena becoming very marked. Later the viscosity is lost, possibly due to the increased imbibition of water.

When observed in body fluid, the cells tend to keep their irregular shapes. Spermatocytes exhibit slow amœboid movements. Isolated cells, however, soon become spherical. They also become spherical and swell on injury as when they are punctured with a needle.

The mitochondria in the primary spermatocyte of *Disosteira* form a voluminous granular network surrounding the nucleus, plainly visible in the fresh unstained cell. The delicate tracery of the mitochondrial structures in this, and in subsequent, stages is shown beautifully with Janus green, beside which similar structures seen in fixed material appear crude and in many respects erroneous. If the Janus green stain be heavy, its coagulative effect is apparent in the increase and clumping together of the granules. If the cell be torn, the cytoplasm goes into solution and the stain very soon fades out, the granules swell and coalesce, forming irregular lumpy masses which persist for a long time.

During metaphase the mitochondrial network is pulled out into a spindle-shaped structure investing the viscous kinoplasmic material. Tearing of the cytoplasm causes a loss in the bipolar arrangement of the cell structures, the mitochondrial strands wrinkle and the whole spindle becomes distorted. The chromosomes scatter. Within a few minutes the relatively dense kinoplasmic mass goes into solution leaving the mitochondrial network with the chromosomes irregularly dispersed inside. In one such case two spermatozoa corkscrewed their way between the meshes of the mitochondrial spindle. Whenever their tails touched the viscous material of the meshes violent lashings were necessary to set themselves free. One struck its head against a mesh and was held prisoner for several minutes until the viscosity of the material was decreased during the dissolution process. The other spermatozoon hit a chromosome which stuck to its tail and the spermatozoon twirled away dragging off the chromosome.

During anaphase and telophase the granules and strands of the mitochondrial network are lengthened into delicate filamentous threads lying between the two groups of chromosomes. These are the interzonal filaments or the spindle-rest described in fixed material. As constriction between the daughter cells progresses, the tension of the fila-

ments diminishes. Their tips vacuolize and appear lumpy, giving evidence again of a network arrangement of granules. As the constriction deepens, the cluster assumes the form of an hour-glass. The Janus green stain now disappears at the middle as if the mitochondrial material were drawn away or had gone into solution. In late telophase the substance of one daughter cell may be torn away from the other cell leaving the mitochondrial filaments projecting in naked strands which soon wrinkle and curl and finally coalesce into a lumpy mass.

Cells in late anaphase and telophase may be caused to assume a spherical shape by mechanical agitation or tearing with the needle. The mitochondrial spindle is then very much distorted, the filaments become wrinkled and tangled. At the end of the cell division, each daughter cell contains a cluster of mitochondrial filaments which have already begun to be transformed into a granular network mass which gradually spreads around the nucleus. The mitochondria are not stable structures. Granules at one moment may draw out into threads, or coalesce with their neighbors, or go into solution, freshly formed granules replacing them.

In the spermatid the mitochondria mass at one side of the nucleus to form the Nebenkern. The mitochondrial granules, at first loosely distributed, soon collect into a compact body which stains a solid blue with Janus green. On dissecting the Nebenkern out of the cell, it disintegrates into granules which persist as such for some time.

The development of the axial filament was closely followed in the cockroach. It originates in connection with an apparent sloughing off of material from the surface of the Nebenkern. The coiled filament thus formed is bordered on two sides with a longitudinal row of granules collected at very regular intervals in small uniform clumps. The filament itself does not stain with Janus green, the bordering granules, however, become intensely blue. One may watch the filament gradually uncoil and loosen from the Nebenkern. One end is inserted in a conical knob, (the blepharoblast), on the surface of the cell nucleus. As it uncoils, it forms a loop curving along the periphery of the cell. The uncoiling is accompanied by an oscillatory movement which begins at the knob and passes in a wave along the filament. This movement gains in strength until the whole body of the cell is thrown into ever recurring waves. The movement is instantly arrested when the cytoplasm is torn by the needle. The cytoplasm then goes into solution and the filament either straightens out or deepens its curve possibly according to the character of the wave at the moment the spermatid is torn. The filament remains attached to the nucleus and may be dragged about with a needle. It is elastic and rigid and keeps its shape perfectly for the short time before it goes into solution. During the process of its elongation the spermatid is very susceptible to touch. A slight prick with the needle will cause it to assume a spherical shape. This is accompanied by a distortion of the double row of granules alongside the axial filament so that one may observe the wave pass along one row slightly ahead of that along the other.

When examined in Ringer's fluid or when the spermatid is disturbed by the needle, the clumps tend to round off in the form of vesicles. This is especially noticeable in the case of the two largest clumps close to the nucleus. Such an appearance is commonly met with in fixed material. As the filament straightens, the cell is drawn out into an attenuated body. The granules along the filament coalesce to form two narrow uniformly homogeneous bands which extend alongside the spherical nucleus to the anterior tip of the spermatid. The nucleus condenses into an optically homogeneous and highly refractive body which gradually lengthens into the rod shape of the mature spermatozoon. A large double clump of granules which lies immediately behind the nucleus condenses and forms the neck piece. The throwing off of clumps of cytoplasm was never observed except in preparations in salt solutions or in old body-fluid preparations where such cytolytic action was apparent in all the cells present.

The perforatorium of the ripe spermatozoon tapers off in the form of a corkscrew. In Ringer's fluid it swells into a bleb-like process and as such is figured by Duesberg and Morse. The tail has two movements, a whip-like lash and a twirl, its base being used as a pivot. These two movements whirl the spermatozoon forward in a corkscrew fashion. It may be noted that the lashing movement of the spermatozoon tail is directly comparable to the waving of the axial filament within the spermatid.

In conclusion I wish to emphasize the following points drawn from this and from my previous paper:

1. As far as nuclear structures are concerned the study of fresh material corroborates, in many interesting details, the observations made in fixed material. Both methods are necessary for a proper understanding of the structures. Our present fixing methods, however, are useless for the study of cytoplasmic and mitochondrial structures and should be replaced by the study of fresh material.

2. "Physiological" salt solutions are more or less injurious to the cells studied which are normally bathed by organic fluids, *i. e.*, liquid colloids.

3. Puncture of a cell by a needle causes irreparable injury. When the injury is slight it at first hastens the normal reversible changes in the physical states of the colloids in the cell but soon transforms them to an abnormal condition from which the cell does not recover.

4. Injury to the cell is always followed by swelling accompanied by an increased inhibition of water.

5. A tension exists in the cell during division which is immediately lost when any part of the cell is torn.

6. Amœboid activities are prevalent among the germ cells. In this way extensive movements occur within the cysts of the testis follicle. When set free in a liquid medium, the amœboid processes are very soon retracted and the cells assume a spherical shape.

The movement in waves of the axial filament of the spermatid starts at the conical knob on the nucleus and accompanies the uncoiling of the filament from the surface of the Nebenkern.

7. The staining of the mitochondria by Janus is probably not due to a chemical combination. In time the stain fades out of the cell. If the stained structure be brought into immediate contact with a liquid it is washed out almost immediately.

8. Janus green, if used in sufficient concentration, will stain the nuclear structures. The dye is reduced to the red safranin even in the presence of abundant air. This has been observed in all stages of the germ cells and also in motile spermatozoa. Such cells, however, soon die. Dead cells take up the blue stain readily, the nuclear structures showing beautifully.

9. Janus green, being a basic dye, coagulates albuminous substances. In living cells this coagulating effect is very noticeable. The stain, therefore, can not be used as the sole means for identifying mitochondria.

10. The mitochondria, in the Orthopteran germ cell, are in accord with those studied by the Lewises[3] in the tissue cells of the chick. They can not be classed as persistent structures. They pass from a granular stage into strands; they may coalesce into homogeneous masses; they disappear and reappear and must be merely changes in physical states of the colloids which compose the cytoplasm.

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SOME NEW CASES OF APOGAMY IN FERNS. PRELIMINARY NOTE

SEVERAL cultures of *Aspidium tsussimense, Pellæa adiantoidis* and *Lastrea chrysoloba* were made beginning June 25, 1914. The spores were sown on sphagnum, which was first placed in small stender dishes, saturated with a one-tenth-per-cent. Knop's solution, and then thoroughly sterilized in an oven.

[3] M. R. and W. H. Lewis, "Mitochondria in Tissue Culture," SCIENCE, N. S., XXXIX., p. 330, 1914.